forms of the present population. Dr. Studer suggests that the Rhaetian short-headed type may be referred to the old dwellers of the Stone period, in which case the prevalent dark hair, eyes, and skin of the present natives of Graübünden may recall the aspect of the older prehistoric race. There is also a large dark population about the lakes in Canton Berne.

M. VERNET has recently made a number of physiological observations on himself during eighteen ascents of high Alpine summits (between 1680 and 4638 metres in height). He finds that the strong muscular efforts made both in mounting and descending caused a rise of temperature of about 1·64° to 1·70° C. on an average; a rise in the pulse from about 75 to 83 in a minute, and an increase in the respiratory acts from about 21 to 25 in a minute. A few hours' rest after the effort ceased brought back the temperature to its normal value. Other muscular efforts, such as riding, wood-sawing or chopping, &c., had quite the same effect. The author's observations are detailed in the *Archives des Sciences*.

THE School of Anthropology, created a few years ago under the auspices of the city of Paris, has opened its 1885–86 session. The course of lectures delivered by M. de Mortillet on prehistoric anthropology will be illustrated for the first time by a series of projections. English anthropologists will learn with pleasure that M. Gabriel de Mortillet, who was one of the companions of Agassiz, has been elected representative of the Seine et Oise Department.

THE engineers of the French Service are establishing a telephonic communication between Paris and Rheims, 160 kilometres from Paris. The Paris terminus of this line will be the Exchange. A sum of one franc for each five minutes will be charged for conversation. As soon as this line is finished the work will begin of connecting Rouen with Paris (126 kilometres). Rouen has been already connected with Havre, 78 kilometres distant, by a telephonic line. Conversation between these two cities is very easily held. It is the success of this system which led to further extension on larger distances.

ON October 9, between 9 and 10 a.m., two severe shocks of earthquake were felt on the Lis Island, in the parish of Sorunda, in Sweden. In the school-house, while teaching was going on, two severe shocks were felt like two blows from an enormous hammer in the north-western corner of the building. In this corner the windows rattled, the floor swayed, and rumbling like that of distant thunder was heard. Simultaneously a great thunderstorm passed over the district, accompanied by heavy rain. It has, however, been ascertained beyond doubt that the shocks were not due to the former, as the shocks were felt by many persons out of doors. The earthquake went from west to east.

SINCE 1880, when diggings for amber were commenced under the Smaland Peninsula in East Prussia, the yield of the veins here has greatly increased. In 1864 the revenue was 1700*l.* against 25,000*l.* in 1883.

MR. WILLIAM CAMERON, F.G.S., the Singapore papers state, has been appointed *Honorary* Explorer and Geologist to the Straits Settlements. "Honorary Explorer" is a curious office, and we cannot recollect ever having heard of one before; but as Mr. Cameron, it is to be presumed, has accepted these two honorary offices, they must be of some assistance to him in his explorations in the Malay Peninsula. One so rarely hears of an Honorary Colonial governor, secretary, treasurer, or other official, that an "Honorary Colonial Explorer" is something of a *rara avis*, and as such deserves to be specially chronicled.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♂), a Bonnet Monkey (*Macacus sinicus*] ♀) from India, presented by Mr. C. E. McCheane; a Macaque Monkey (*Macacus cynomolgus* ♂) from India, presented by Mr. C. Canfor; a Mexican Deer (*Cariacus mexicanus* ♂) from Florida, presented by Mr. G. B. H. Marton; two Spotted-tailed Dasyures (*Dasyurus maculatus* ♂ ♀), three Short-headed Phalangers (*Belideus breviceps* ♂ ♂ ♀) from South Australia, presented by Sir W. C. F. Robinson, K.C.M.G.; an Osprey (*Pandion haliætus*), captured at sea, presented by Capt. Morgan; an Alexandrine Parrakeet (*Palæornis alexandri*) from India, presented by Mr. Chas. Williams; a Black-eyebrowed Albatross (*Diomedea melanophrys*) from False Bay, South Africa, a Vulturine Eagle (*Aquila verreauxi*) from South Africa, a Sharp-headed Lizard (*Lacerta oxycephala*) from Madeira, presented by Mr. W. Ayshford Sandford, F.Z.S.; a Black-crested Eagle (*Lophoætus occipitalis*) from South Africa, presented by the Lady Robinson: a Rufescent Snake (*Leptodira rufescens*), a Hoary Snake (*Coronella cana*), a Keeled Euprepes (*Euprepes carinatus*), five Rough-scaled Zonures (*Zonurus corydlus*) from South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; three Grey-breasted Parrakeets (*Bolborhynchus monachus*) from South America, a Pale-headed Broadtail (*Platycercus pallidiceps*) from North-East Australia, deposited; two Lesser Vasa Parrakeets (*Coracopsis nigra*) from Madagascar, purchased.

ASTRONOMICAL PHENOMENA FOR THE WEEK, 1885, *NOVEMBER* 8–14

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on November 8

Sun rises, 7h. 8m.; souths, 11h. 43m. 54·1s.; sets, 16h. 20m.; decl. on meridian, 16° 43′ S.: Sidereal Time at Sunset, 19h. 32m.

Moon (two days after New) rises, 8h. 28m.; souths, 13h. 9m.; sets, 17h. 46m.; decl. on meridian, 16° 33′ S.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	8 34	12 38	16 42	21 42 S.
Venus	11 22	14 54	18 26	26 12 S.
Mars	23 48*	7 0	14 12	13 11 N.
Jupiter	2 34	8 46	14 58	1 33 N.
Saturn	19 17*	3 25	11 33	22 18 N.

* Indicates that the rising is that of the preceding day.

Phenomena of Jupiter's Satellites

Nov.	h. m.		Nov.	h. m.	
8	4 54	II. ecl. disap.	13	4 59	I. tr. ing.
9	5 40	III. occ. reap.	13	7 16	I. tr. egr.
10	4 42	II. tr. egr.	14	4 37	I. occ. reap.
12	6 54	I. ecl. disap.			

The Phenomena of Jupiter's Satellites are such as are visible at Greenwich.

Nov.	h.	
10	20	Venus in conjunction with and 7° 49′ south of the Moon.

OPTICAL THEORIES[1]

THE last general report on Optics which was laid before the Association was read at Dublin by the late Dr. Lloyd in the year 1834, fifty-one years ago. Since then, in 1862, Prof. Stokes dealt very completely with double refraction so far as the elastic-solid theory is concerned, and there is little to add to what he said then. In all branches of his subject the fifty-one years since Dr. Lloyd's report have been most fruitful, and in consequence the mass of papers to be dealt with has been very large.

The report is divided into four sections: the first, which is introductory, deals with the work of Green, MacCullagh, Cauchy, and Neumann, the founders of the elastic-solid theory.

In the second section the more modern writers on the elastic-solid theory are considered—De St. Venant, Sarrau, Lorenz, Stokes, Lord Rayleigh, Kirchhoff, and others.

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[1] Report presented to the British Association by R. T. Glazebrook, M.A., F.R.S.

The third section is devoted to theories in which the mutual action between the matter molecules of the transparent body and the ether is considered as the main cause of refraction, dispersion, and other phenomena.

The chief workers in this field seem to be Boussinesq, Sellmeier, Helmholtz, Lommel, Ketteler, Voigt, and, in his lectures at Baltimore, Sir W. Thomson.

The fourth and last section deals with the electro-magnetic theory of Maxwell, and the developments it has received from the hands of Helmholtz, H. A. Lorentz, Fitzgerald, J. J. Thomson, Rowland, and Glazebrook.

The report is devoted strictly to *general optical theories*. This has been required by the necessities of both space and time, and, as a consequence, the optical papers of many most distinguished workers, such as Fizeau, Jamin, and Quincke, are hardly noticed, except in so far as the results at which they have arrived bear on some point or other of the general theory. There is ample room for a report dealing with optics from an experimental standpoint which should arrange and compare the conclusions of various experimenters on debated points.

Turning, then, to the sections in order: in the second section, which deals with the elastic-solid theory, the optical properties of media are considered on the hypothesis that they arise entirely from differences in the rigidity or in the density of the ether in these media.

While the development of this theory has taught us much, we are driven to conclude that the fundamental hypothesis will not account for all the optical phenomena.

The papers of Stokes on diffraction, of L. Lorenz and Lord Rayleigh on refraction and the scattering of light by small particles, have proved conclusively that we must look to difference of density, or of apparent density, in the media to explain the phenomena, and not, as was suggested by MacCullagh and Neumann, to difference of rigidity.

With this conclusion Fresnel's hypothesis that the direction of vibration in polarised light is normal to the plane of polarisation is necessarily connected.

On the other hand, the only strict elastic-solid theory of double refraction is that of Green, and according to it, if we suppose the medium initially free from stress, the direction of vibration lies in the plane of polarisation, and even this conclusion is only arrived at by supposing certain arbitrary relations between the coefficients.

These two conclusions, then, of the elastic-solid theory are hopelessly at variance. It is true that, by supposing the medium initially to be in a state of stress, Green arrived at a second theory in agreement with his theory of reflection, but this agreement is gained by the introduction of a second set of arbitrary relations.

In connection with this point I should mention that it seems to me that Green's theory of reflection can be reconciled with experiment by adopting the suggestions of Lord Rayleigh as to the refractive index of the media for the normal waves.

The elastic-solid theory also fails to explain anomalous dispersion and metallic reflection. Cauchy's expressions for the mathematical analysis of the latter agree with experiment; but then they require that μ^2 should be complex quantity with its real part negative, and this involves the instability of the medium as regards the problem of ordinary dispersion. Cauchy's theory has been advanced by the writings of Sarrau; while the investigations of Ketteler have shown that a formula of the form—

$$\mu^2 = A + B\lambda^2 + \frac{C}{\lambda^2} + \frac{D}{\lambda^4}$$

agrees very closely with experiment.

Stokes has given us an explanation of aberration by showing us that we may suppose the earth to move through space and carry the surrounding ether with it, the ether at some distance from it being at rest; provided that the motion thus produced in the ether be irrotational, all the known phenomena of aberration will follow. And he has further shown us that any small tendency to variation from such irrotational motion will call into action the rigidity of the ether, and be propagated into space with the velocity of light. According to the views developed in these papers of Prof. Stokes, the ether may be treated as a perfect fluid for the large motions produced in it by the motion of the earth; while at the same time it has rigidity, and obeys the equations of an elastic-solid for such small motions as are involved in the passage of a wave of light.

According to the views dealt with in the second section, the ether is of the same density and rigidity in all transparent media. For such media, however, its motions are affected by the presence of the molecules of the medium. Some of the energy of the incident light may be used up in setting these matter-molecules into motion. The amount required for this depends on the nature and properties of the matter-molecules, and hence is different for different media and for waves of different length. This gives rise to reflection and refraction.

There are indications in the writings of Fresnel that he looked to some explanation himself, but it seems to be to Boussinesq that we owe the first real development of the theory.

He forms the equation of motion of the ether and matter combined on the supposition that the forces on the matter arising from the direct action of surrounding matter are owing to the smallness of the displacements negligible. He then supposes that the matter displacement U may be expanded in terms of the ether displacements u and its differential coefficients, and finally arrives at equations of the form

$$(\rho + A\rho')\frac{d^2u}{dt^2} = B\Delta^2 u + C\frac{d\delta}{dx}, \text{ \&c.}$$

where

$$\delta = \frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}.$$

B and C involve the period, ρ is the density of the ether, and ρ' of the matter; and hence dispersion is accounted for. Double refraction is explained by supposing A to be a function of the direction, while B and C remain constant; and for this reasons are given, and it is shown that on certain other hypotheses this leads to Fresnel's theory. This theory deals also with the phenomena of elliptic polarisation in quartz, and of aberration.

In Boussinesq's theory the motions of the matter particles are neglected, except in so far as they act on the ether and modify its motion. Sellmeier was the first to see that reflection and refraction would be profoundly modified in the cases in which the free period of the matter particles agrees with that of the incident light, and when, therefore, the energy in that light is absorbed in setting the matter into motion. His work was continued by Helmholtz, Lommel, Ketteler, Voigt, and Sir W. Thomson.

The equations of motion employed by all these writers are the following:

$$\rho\frac{d^2u}{dt^2} = X + A + X',$$

$$\rho'\frac{d^2U}{dt^2} = \mathfrak{X} + A + \mathfrak{X}'.$$

In these equations X represents the force on the ether, in the element of volume considered, arising from the surrounding ether; X', from any external impressed forces; and $\bar{A}$, from the matter; while $\mathfrak{X}$, $\mathfrak{X}'$, and A, are the same for the matter. According to all $X = X' = 0$. We must also have $\bar{A} + A = 0$. The difference in the theories consists in the different forms given to A.

Sellmeier, Thomson, and Helmholtz put $A = \beta^2(u - U)$. Lommel puts $A = \beta^2\frac{d}{dt}(u - U)$. The results of Ketteler's theory are, except in one small and, I venture to think, non-essential point, identical with those found by putting $A = \beta^2\frac{d^2}{dt^2}(u - U)$ (Ketteler obtains his equations in a different form from the above). Voigt investigates the general form possible for A consistent with the propagation of a plane wave and the conservation of energy. He finds

$$A = \left(\alpha^2 + \beta^2\frac{d^2}{dt^2} + \gamma^2\frac{d^2}{dz^2} + \delta^2\frac{d^4}{dt^2\,dz^2}\right)(u - U).$$

For the value of X all the authors put—taking waves travelling parallel to z—

$$X = e\frac{d^2u}{dz^2};$$

while Voigt adds the term $\frac{dp}{dz}$. For $\mathfrak{X}$ all but Voigt and Thomson write—

$$\mathfrak{X} = aU + b\frac{dU}{dt}.$$

Thomson objects to the term $\frac{dU}{dt}$ as involving a viscous expenditure of energy. Voigt argues, with Boussinesq that in ordinary transparent media U is so small compared with u that it may be neglected, and puts it zero everywhere.

The results of the various theories differ in the form they give for the dispersion formula. Lommel's theory has been shown by Voigt to be untenable. The theories of Helmholtz, Thomson, and Sellmeier lead, when b is small, to the same result, and give

$$\mu^2 = 1 + \frac{\beta^2 \tau^2}{\rho} \left\{ 1 + \Sigma \frac{q \tau^2}{\tau^2 - \kappa^2} \right\},$$

which Ketteler's gives

$$\mu^2 = 1 + \frac{\beta^2}{\rho} + \Sigma \frac{D}{\tau^2 - \kappa^2}.$$

τ is the period of the ether vibration, κ of the matter vibration, and q, D, &c., are functions of the constants.

Voigt's formula, since he does not consider the matter motion, is different and not so general.

With regard to these formulæ, I am not aware that Helmholtz's has been tested by comparison with experiment. Ketteler's has, and agrees excellently over a long range of values of τ.

Double refraction is generally explained by supposing β^2 to be a function of the direction; but, as Sir W. Thomson has pointed out, this involves for Helmholtz's theory—he did not, however, apply his formulæ to crystals—dispersion with double refraction. For Ketteler's theory this is not the case. μ can be a function of the direction independently of τ.

The mechanism which would make the action between the matter and ether in each element of volume a function of the acceleration is perhaps not so easy to conceive as that supposed by Helmholtz and Thomson; but still Ketteler's theory seems to overcome some of the difficulties inherent in the latter.

Either of these theories can be shown to lead to Fresnel's wave-surface, provided we do not consider it necessary that the vibrations should lie in the wave-front. The vibration, as indeed Ketteler and Boussinesq have pointed out, will be normal to the ray. In all other respects Fresnel's construction will hold.

Ketteler and Voigt have tried, without much success, to apply their theories to reflection and refraction.

Thomson, in that most valuable appendix to his Baltimore lectures, has given a complete theory. This can be readily adapted to Ketteler's theory, and the results in many points agree in a striking manner with experiments both for transparent and opaque bodies. The occurrence of a real negative value for μ^2 is explained by the supposition that the period of the incident light is higher than the highest possible mode of vibration for the matter-molecules in the medium.

The last section deals with Maxwell's electro-magnetic theory of light.

Electro-magnetic disturbance travels in air with a velocity equal to that of light; and in a double refracting medium obeys Fresnel's laws. The difficulty lies in giving a physical explanation of light motions, and of accounting for the mechanical structure of the ether required by the theory. No complete theory of dispersion has yet been given. The work of Willard Gibbs does not explain why there is no dispersion in a vacuum. The objection made to Cauchy's theory holds good. It is probable that some theory such as is developed in the third section may be successfully applied to the electro-magnetic disturbance.

The theory has the great advantage of connecting naturally with the theory of light the important electro and magneto-optical discoveries of Faraday, Kerr, Kundt, and Quincke, and to the development of this much is due to Prof. Fitzgerald. The theory of reflection and refraction as at present developed is only approximate.

ELECTROLYSIS

PROF. LODGE opened the discussion at the Aberdeen meeting of the British Association on Electrolysis by reading a paper, the notes of which have already appeared in NATURE.

Sir W. Thomson referred, in his remarks on Prof. Lodge's paper, to a matter of importance in electro-plating—viz. the selection which takes place in the electrolysis of solutions containing several salts, as, for instance, in the electrolysis of copper sulphate containing ferrous sulphate, which, when decomposed by a strong current gives a deposit containing impurities, whereas a slower decomposition yields a very pure deposit. Sir W. Thomson spoke also of the necessity for the careful investigation of those cases in which the formation of deposits between the electrodes had been observed, and it would be important to know whether deposits could be formed in the line of conduction without a nucleus at all. Such matters are of importance to physiology, indicating a possible danger in the passing of long continued currents through the human body.

Prof. Schuster explained the views propounded by Von Helmholtz in his recent papers on this subject. Helmholtz explains the phenomena of electrolysis by assuming a different attraction of different chemical elements for electricity. If this be admitted, most of the difficulties connected with the phenomena of contact electricity disappear. In electrolysis the element (say hydrogen) charged with positive electricity travels to the negative electrode and forms a coating over it. Any electromotive force, however small, is sufficient to produce this effect, as no work is done. The hydrogen does not appear as free hydrogen, however. It is only liberated when the electromotive force is sufficient to produce a transfer of the positive electricity from the hydrogen molecule to the electrode. When the dissociated elements appear in a neutral state an interchange of the electricities of the elements must have occurred before dissociation. In this way we may explain the conversion of stannic in stannous chloride, which was mentioned by Prof. Armstrong in his address. Prof. Schuster did not think that Prof. Lodge had laid sufficient stress on the fact that in very dilute solutions an ion has the same rate of transference, no matter with what element it was combined. This fact affords strong evidence in favour of the above views, from which it follows as a necessary result. Prof. Schuster also explained his own views of the discharge of electricity in gases. He believes that the phenomena present some analogy to those exhibited in electrolysis of liquids. The phenomena exhibited at the negative pole are, he thinks, due to dissociation of the compound molecule. They do not appear in the case of monatomic mercury vapour. Experiments which he hopes to conclude in the next few months will decide whether or not the law of the constancy of molecular charge holds.

The next contribution to the discussion was a paper by Dr. C. R. Alder Wright, containing an account of the nature of his investigations, conducted with the view of measuring Chemical Affinity in terms of E.M.F.

On the Sensitiveness to Light of Selenium and Sulphur Cells, by Shelford Bidwell, M.A., LL.B.—The author suggests that the operation of annealing in the making of selenium cells increases the sensitiveness to light by promoting the combination of the selenium with the metal of the electrodes, forming a selenide which completely surrounds the electrodes, and is, perhaps, diffused throughout the selenium when in a liquid condition; further, that the apparently improved conductivity of the selenium, together with the electrolytic phenomena which it exhibits, are to be accounted for by the existence of this selenide. This view finds considerable support in the fact that cells, constructed with sulphur, replacing the selenium and containing a proportion of silver sulphide, are all more or less sensitive to light, and exhibit properties of annealed selenium. The author also read a paper *On the Generation of a Voltaic Current by a Sulphur Cell with a Solid Electrolyte*, a short account of which has already appeared in NATURE (vol. xxxii. p. 345).

MOLECULAR WEIGHTS

THE discussion on the Molecular Weights of Liquids and solids was opened in Section B of the British Association by the reading of a paper by Prof. A. W. Reinold, F.R.S., the subject of which was the *Size of Molecules*. In this paper an account was given of the different lines of argument by which Sir W. Thomson has been led to form an estimate of the size of molecules. The estimate is based upon four lines of argument—the first, from the refractive dispersion of light; the second, from the phenomena of contact electricity; the third, from liquid films; and the fourth, from the kinetic theory of gases. All four agree in showing that in liquids and transparent solids the mean distance between the centre of contiguous molecules is something between 1/10th and 1/200th of a millionth of a millimetre. Recently Exner (*Monatschrift für Chemie*, vi. 244-278) has proposed another method for estimating the diameter of gaseous molecules, the results obtained by this method being slightly smaller than those deduced from the above. The author gave an account of his experiments on soap-films, conducted conjointly with Prof. Rucker (NATURE, vol. xxxii. p. 210), the results of which are